DOCUMENT RESUME

ED 101 552 FL 006 213

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TITLE Nasal Vowels. Working Papers on Language Universals, No. 12.
INSTITUTION Stanford Univ., Calif. Committee on Linguistics.
PUB DATE Nov 73
NOTE 37p.

EDRS PRICE MF-$0.76 HC-$1.95 PLUS POSTAGE
DESCRIPTORS *Contrastive Linguistics; *Diachronic Linguistics; *Language Universals; Linguistic Theory; Phonemics; Phonetics; Phonological Units; Phonology; *Synchronic Linguistics; *Vowels

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This paper is an investigation of nasal vowels from both a synchronic and a diachronic point of view. Data from over 50 languages have been examined (some languages in much more detail than others) in an attempt to distinguish the aspects of vowel nasalization that are "universal" from those phenomena that are language-specific. This study is chiefly concerned with such questions as the following: (1) What is a nasal vowel? (2) Why do nasal vowels arise? (3) What is the historical source of nasal vowels? (4) What is the synchronic origin of nasal vowels? (5) How are nasal vowels used? (6) How do systems of nasal vowels change and disappear? (Author/KM)

Working Papers on Language Universals
No. 12, November 1973
pp. 1-36

RESEARCH PAPERS

NASAL VOWELS

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ABSTRACT

This paper is an investigation of nasal vowels from both a synchronic and a diachronic point of view. Data from over fifty languages have been examined (some languages in much more detail than others) in an attempt to distinguish the aspects of vowel nasalization which are 'universal' from those phenomena which are language specific. We will be chiefly concerned with such questions as the following:

(1) What is a nasal vowel?
(2) Why do nasal vowels arise?
(3) What is the historical source of nasal vowels?
(4) What is the synchronic origin of nasal vowels?
(5) How are nasal vowels used?
(6) How do systems of nasal vowels change and disappear?

1. Some preliminary definitions

What is a nasal vowel? From a physiological point of view one might be tempted to define a nasal vowel (NV) as a vowel produced with the velum at least partially lowered so that air may escape through both the mouth and the nose. However, linguists have long recognized that the mere physical presence of nasality is not in itself sufficient to define what have traditionally been called NV's. For example, it is well known that vowels adjacent to nasal consonants (NC) are usually at least partially nasalized, so that ENGLISH man is phonetically [mæ̃n]. The fact that the vowel of man is phonetically nasalized has not, in general, prevented linguists from considering it an 'oral' vowel, phonemically, for the simple reason that such nasalization is phonetically conditioned by the surrounding segments. Thus, linguists have insisted that the nasalization of a NV must be in some sense inherent (intrinsic, phonemic, underlying, non-contingent, etc.) in the vowel, and not phonetically conditioned. The term NV has consequently been reserved for vowels that (I) show marked nasalization and (II) contrast phonetically with the corresponding oral vowel. The vowel [æ] of man is not a NV according to these criteria because condition (II) is not satisfied. There is no form *[mæn] in ENGLISH which contrasts with [mæ̃n]. More strongly, ENGLISH phonological structure does not allow phonetic forms such as *[mæn] since such forms violate an obligatory phonetic rule which nasalizes all oral vowels in a certain phonetic context.

This, however, raises the question of how allophonic nasalization such as is found in ENGLISH man is to be specified in a grammar. If the articulatory accomodation between an oral vowel and a following NC resulted in the same strength of nasalization in all languages, then the problem could be disposed of quite simply by positing a single universal rule which would specify the degree to which vowels are nasalized when preceding (or following) NC's. This does not appear to be the case, however, with respect to rules of accomodation between vowels and velar stops. Ladefoged (1971b: 55) points out that "in French the influence of the vowel on a following velar stop in words such as pique and pâque seems to be far greater than the influence of the vowel on the following stop in English words such as peak and pock. We do not know if this is entirely due to differences in the targets of the vowels in French and English; or whether, in addition to differences in targets, there are also differences in the conjoining rules. My present guess is that conjoining rules are not entirely language independent." In a similar vein Robins (1953:326) writes that "consonants of the velar group enjoy the greatest phonetic latitude of any of the Sundanese consonants in their realization, being articulated as pre-velar, mid-velar, or post-velar according to the nature of the preceding or following vowel, with noticeably greater variation than occurs in the Standard English k- and g- sounds in their different phonetic contexts."

It seems to me even less likely that the 'conjoining rules' for vowels and NC's can be universally specified. In PORTUGUESE any NC appreciably nasalizes a preceding vowel (cf. Morais-Barbosa, 1962: 691-2),

while in FRENCH such allophonic nasalization is far less pronounced. We might then specify allophonic nasalization in one of two ways. Either we postulate a set of universal conjoining rules, and then further specify how individual languages differ from the predictions of these universal rules, or else we simply posit language specific conjoining rules. The latter approach is somewhat unattractive in that it ignores the fact that there is certainly some natural accomodation between segments that is a direct consequence of the physiology of the vocal tract. The former hypothesis, however, poses the problem of how one is to determine just what this 'natural accomodation' is, and why languages differ from it in one direction or another. Let us summarize the above comments with the observation that the specification of allophonic nasalization is a complex question that merits further investigation.

PORTUGUESE, unlike ENGLISH, is a language which is traditionally considered to have NV's. On the basis of such minimal pairs as

(1) [vi] 'I saw'
(2) [vĩ] 'I came'

many linguists have argued that the nasalization of the vowel in (2) is an intrinsic property of that vowel, and serves to distinguish (2) from (1). According to this view speakers differentiate (1) and (2) by the presence or absence of nasalization in the vowel.

Many European structuralists (cf. also Trager, 1944), and more recently generative grammarians, have argued that conditions (I) and (II) are themselves not sufficient to establish the intrinsic nature of vowel nasalization. On the basis of such minimal pairs as FRENCH

(3) [bo] 'beautiful' (m. sg.)
(4) [bõ] 'good' (m. sg.)

they argue that in spite of the surface contrast in FRENCH between [o] and [õ], the feature [+nasal] is not an inherent property of the vowel in (4), but is rather conditioned, not by phonetic structure, but by the morphophonemic structure of FRENCH. Thus, in order to show that [bõ] 'good' (m. sg.) and [bɔn] 'good' (fem. sg.) represent a single lexical item, both surface forms are derived from the same underlying representation: /bon-/

PHONOLOGICAL LEVEL	/bon/	/bon+ə/
Vowel Nasalization	bõn	
n Deletion	bõ	
Schwa Deletion		bon
Vowel Lowering		bɔn
PHONETIC LEVEL	[bõ]	[bɔn]

Under this more restricted view the feature of nasality is considered to be intrinsic only if it cannot be independently motivated from either phonetic or morphophonemic structure. In ENGLISH man the nasality of the

vowel is phonetically conditioned; in FRENCH bon it is morphophonemically conditioned; in PORTUGUESE vim it is presumably unconditioned.

On the basis of the above discussion we may define three kinds of NV's:

Definition 1: A phonetic NV is a vowel which is phonetically nasalized.

Definition 2: A phonemic NV is a vowel which (I) is phonetically nasalized, and (II) where the feature [+nasal] is not predictable in terms of phonetic structure.

Definition 3: A phonological NV is a vowel which (I) is phonetically nasalized, and (II) where the feature [+nasal] is not predictable in terms of either (a) phonetic or (b) grammatical structure.

Furthermore, it should be emphasized that there is not necessarily a direct correlation between the strength of nasalization and the type of NV (i.e. phonetic, phonemic, or phonological), though we might expect that, in general, phonological and phonemic NV's would show greater nasality than phonetic NV's (this is surely true of FRENCH). However, Jackson (196?: 42) indicates that in the LÉONAIS dialect of BRETON allophonic nasality may at times be as strong as phonemic nasality, and Ferguson and Chowdhury (1960: 37) report that in BENGALI "it sometimes happens that the nasal quality of a phonemically oral vowel next to a nasal consonant is more striking phonetically than the nasal quality of a phonemically nasal vowel." In POLISH the strength of nasality in (phonological) NV's is at times so slight that some linguists have argued that such vowels are in fact not nasalized at all (cf. Zagórska-Brooks, 1968). Surely a thorough cross-language comparison of the strength of nasality in NV's would show even more overlapping than occurs in the specific languages cited above.

Note that the set of phonetic NV's subsumes the set of phonemic NV's, which is turn subsumes the set of phonological NV's:

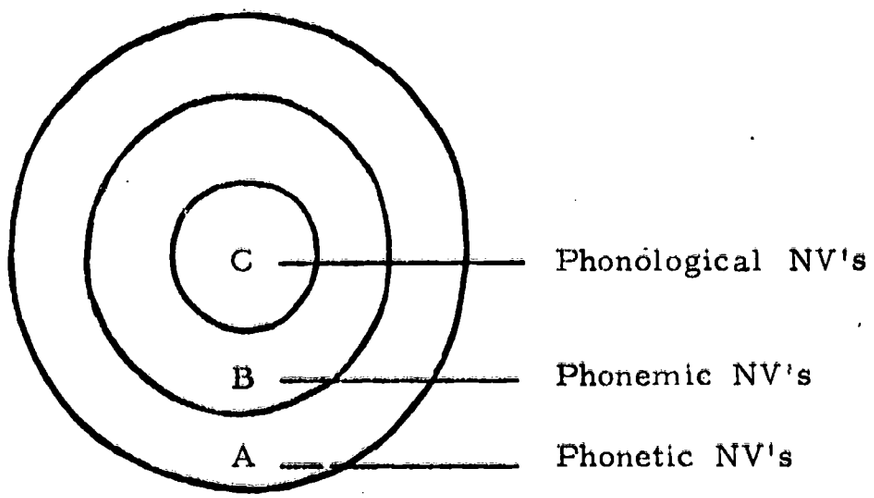


Diagram 1

While strictly speaking a phonological NV is both a phonemic and a phonetic NV, and a phonemic NV is also a phonetic NV, henceforth when we speak of phonetic NV's we will be referring only to phonetic NV's which are not at the same time either phonemic or phonological NV's (area A in Diagram 1). Similarly, by phonemic NV's we shall mean only those phonemic NV's which are not also phonological NV's (area B in Diagram 1). Phonological NV's will, of course, be those NV's found in area C of the diagram. By definition, the feature [+nasal] is an inherent property of a vowel only if that vowel is a phonological NV.

Whatever other merits the above taxonomy may have, it is indispensable in interpreting the available literature, where a failure to distinguish different kinds of NV's has often led to misunderstanding, and in many cases sterile debate. For example, it is futile to attempt to determine the date at which NV's arose in a given language if one does not specify what type of NV's (phonetic, phonemic, or phonological) he has in mind. All too often such terminological questions have taken the guise of substantive discussion.

2. Previous studies

One of the earliest attempts to specify universals relating to vowel nasalization is Issatschenko (1937). While his main thesis (that oral vowel systems 'control' NV systems in the sense that if the oral vowels form a triangular (quadrangular, etc.) pattern, then the NV's must also constitute a similar pattern) appears today somewhat dubious, we may still credit him with explicitly recognizing that the relationship between oral vowels and NV's in a given language is far from arbitrary. This relationship is frequently, if not always, quite intimate, from a synchronic as well as from a diachronic perspective. Issatschenko was certainly on firm ground when he wrote that "on peut affirmer d'une manière générale que les systèmes des voyelles nasales sont plus pauvres que ceux des voyelles orales." (270) (cf. Ferguson's universal 11 below). Nevertheless, Issatschenko posited a number of other universals which we now know to be incorrect: e.g. (1) No language may possess only one NV. 2) Denasalization never affects a single vowel, but rather must affect the whole class of NV's simultaneously. 3) NV's are always a proper subset of the oral vowels. 4) No language opposes long and short NV's.

A more recent investigation of universals, with respect to both NV's and NC's, is found in Ferguson, 1963. In that article Ferguson proposed fifteen universals, five of which deal directly with NV's:

10. No language has NV's unless it also has one or more P[rimary] N[asal] C[onsonant]'s.

11. In a given language the number of NV's is never greater than the number of nonnasal vowel phonemes.

12. In a given language the frequency of occurrence of NV's is always less than that of nonnasal vowels.

13. When in a given language there is extensive neutralization of NV's with oral vowels, this occurs next to nasal consonants.

14. NV's, apart from borrowing and analogical formations, always result from the loss of a PNC.

A number of observations may be made concerning these five universals. First of all, as Ferguson notes, universal 10 is really a corollary of his first universal:

1. Every language has at least one PNC in its inventory.

Ferguson mentions three languages as exceptions to this universal. More recently Thompson and Thompson (1972) have discussed these nasalless languages, indicating that each belongs to a different language family. The authors also cite other nasalless languages not referred to by Ferguson.

In addition to the languages discussed by Thompson and Thompson, which lack NC's phonetically, several linguists have recently argued that some AFRICAN languages lack NC's phonologically, though not phonetically. Thus, Schachter and Fromkin (1968), Hyman (1972), and Rouget (1972) all claim that the phonetic NC's of certain KWA languages derive from underlying voiced stops which become nasal when followed by a NV:

/bã/ → [mã]

If indeed NC's do derive from underlying voiced stops in this way, then these KWA languages would constitute counterexamples not only to universal 1, but also to universal 10. Universals 1 and 10 thus appear to represent the normal state of affairs in the vast majority of the world's languages, but here and there exceptions to the rule do seem to crop up.

Greenberg (1966) points out that universals 11 and 12 are in fact deducible from Ferguson's last universal about NV's (i.e. 14). While universals 10-13 represent constraints on synchronic states, universal 14 is diachronic in nature, specifying how NV's may arise. Assuming the validity of universal 14, Greenberg argues that universals 11 and 12 are then simply consequences of the historic origin of NV's. If NV's do indeed develop from earlier sequences of oral vowel + nasal consonant, it follows that the number of NV's cannot exceed the number of oral vowels (universal 11), and furthermore, the frequency of occurrence of the oral vowels + N was surely less than the frequency of oral vowels not followed by N (universal 12). This should not be taken to mean that the frequency of each NV is always less than its oral partner; as Greenberg notes, subsequent merger of NV's may increase the frequency of a NV to the point where it surpasses that of the corresponding oral vowel. Valdman (1959) reports that this is in fact the case for several pairs in FRENCH, and Andrews (1949) claims that in TEMOAYAN OTOMI [ũ] is much more frequent than [u]. Greenberg explains this phenomenon in terms of two additional universals:

(5) A merger of oral vowels always presupposes the merger of the corresponding nasal vowels if they exist.

(6) If nasal and oral vowels merge unconditionally, the phonetic result is always an oral vowel.

The languages we have examined offer numerous examples of distinctions in the oral vowel system which are lacking in the NV system. For example, quite often languages which contrast [e] and [ɛ] have only one NV of e quality (e.g. BRETON, FRENCH, GUJARATI, GUN, MAZAHUA, OGONI, PORTUGUESE, TEWA, and YORUBA). As another example, it is frequently the case that languages which have high, mid, and low oral vowels possess only high and low NV's (e.g. AKAN, ASSINIBOINE, BAULE, IOWAY-OTO, NUPE, TEMOAYAN OTOMI, SCOT'S GAELIC, TOLOWA, and YANKTON-TETON). On the other hand, except for the bizarre arrangement of oral and NV's in ONEIDA, we have discovered no languages with a contrast among NV's not also found in the oral vowel system.

Let us now consider the last two of Ferguson's universals (i.e. 13 and 14). Universal 13 states that "when in a given language there is extensive neutralization of NV's with oral vowels, this occurs next to nasal consonants." While stated in synchronic terms, I believe this universal, too, has a diachronic explanation, as we can see by examining the FRENCH data. At least the following five stages may be distinguished in the history of FRENCH NV's (Cf. Pope, 1934):

1.	bon	bonə
2.	bõn	bõnə
3.	bõ	---
4.	---	bonə
5.	---	bon

In stage 1 vowel nasalization has not yet begun. Stage 2 shows that all vowels are nasalized when followed by a NC. In stage 3 word final NC's are lost, with the result that there is now a surface contrast between V and Ṽ. Now in precisely those contexts where such a contrast is <u>not</u> possible (i.e. where <u>n</u> has not been lost), denasalization sets in. As a consequence of denasalization, then, NV's henceforth appear only where there is no following NC. In other words, because of the elimination, through denasalization, of the redundant feature [+nasal] in the first vowel of [bõnə], NV's and oral vowels are, in effect, neutralized before NC's. In this context we now find only oral vowels (Cf. stage 4). As I understand it, this is what universal 13 is stating in synchronic terms.

However, we must observe that such neutralization is not produced by <u>preceding</u> NC's, which have played no role in the nasalization process. We still find contrasts between oral vowel and NV <u>after</u> NC's (e.g. <u>main</u> [mɛ̃] 'hand' ~ <u>mes</u> [mɛ] 'my'; <u>mon</u> [mõ] 'my' ~ <u>Moe</u> (proper name) [mo]).

Thus, universal 13, like 11 and 12, is best regarded as a synchronic consequence of the diachronic process of vowel nasalization.

Finally, let us turn to universal 14, which says that "NV's apart from borrowing and analogical formations, always result from loss of a PNC." Here again we find that this universal represents the normal state of affairs, but that exceptions to it are found. Before we proceed to our discussion of NV's arising from earlier NC's, it might be appropriate to give a few examples of NV's which do not derive from earlier NC's.

Heffner (1964: 112-4) provides a clear example of NV's arising through analogy. He reports that in some GERMAN dialects the pronunciation of Sohn 'son' has shifted from [zõ:n] to [zõ:]. After this change Floh 'flea' came to be pronounced [flõ:] on analogy with Sohn, so that in Goethe we find the two words rhyming.

With respect to borrowing one may cite Goddard's (1971:140) hypothesis that "the phonological and areal limitations on the nasalization in the Abnaki languages suggest that this innovation was primary in the southern NE languages and diffused northward secondarily ... The spread of an areal feature of vowel nasalization from Iroquoian to Algonquian languages seems indicated." In addition, Chatterji (1970) hypothesizes that certain 'spontaneously' nasalized vowels in BENGALI may in fact have been borrowed from neighboring speech communities.

English itself presents an unusual case of a NV being 'borrowed' from a language in which the original word contained only oral vowels. Many Americans, who are aware (either consciously or unconsciously) that FRENCH has NV's, but do not know FRENCH well enough to use the NV's in the appropriate contexts, pronounce Sorbonne as [sɔrbõ]. The correct FRENCH pronunciation is, of course, [sɔrbɔn], with no NV. It is my impression, however, that the pronunciation of Sorbonne, among Americans not fluent in FRENCH, contains a NV much more frequently than the proper oral vowel.

A final source of NV's is through spontaneous nasalization. Grierson (1922) cites examples of spontaneous nasalization in the INDO-ARYAN languages, and Thalbitzer (1904) discusses similar phenomena in GREENLANDIC. More recently, Ferguson (1963: 59) mentions that "in Iroquoian ... one of the NV's posited for the protolanguage seems, on considerations of internal reconstruction, to have derived from earlier /a/+/i/ or sequences like /awa/." It is not surprising that more often than not spontaneous nasalization affects low vowels, for, as Ladefoged (1971a: 34) points out, "there is usually a variation in the degree of velic opening in accordance with the height of the vowel (high vowels are far less nasalized than low vowels)."

Apart from borrowing, analogy, and cases of spontaneous nasalization, there is one other origin for NV's which has recently been proposed in the

literature, and which does not involve NC's. Hetzron (1969), Matisoff (1970), and J. Ohala (1971a, 1972) all cite cases of NV's arising through contact with glottal or pharyngeal consonants. Hetzron observes that in SOUTH-ETHIOPIC languages we sometimes find non-etymological n's at the end of an initial syllable. For example, AMHARIC and 'one' is derived from *(a)ḥad-. Hetzron proposes to explain this non-etymological n by the following evolution:

ʕ/ḥ + V + C > # ʔ/ḥ + Ṽ + C > # ʔ/ḥ + V + N + C

Presumably SIDAMO speakers, when borrowing the laryngeals /ʕ/ and /ḥ/ from a neighboring language, reinterpreted them as nasalized /ʔ̃/ and /ḥ̃/ since the original pharyngeal sounds were pronounced with a velic opening.

Matisoff notes that "Tibetan ḥ represented some sort of prenasalization of the following consonant," (p.41) and that in some modern TIBETAN dialects "orthographic ḥ- has allegedly acquired a nasal articulation in all cases." (p.41). Matisoff also states that "the relationship between zero initial, ʔ, and nasalization is an intimate one all over Southeast Asia. In CENTRAL THAI, for example, many speakers nasalize words beginning with ʔ-, h-, or a nasal and having the vowel -a:

hâa [hą̂a] 'five'; hăa [hą̆a] 'visit'; ʔaw [ʔą̇w] 'take' " (p.42)

Finally, Matisoff remarks that "certain varieties of BRITISH ENGLISH offers us more exotic, but quite parallel examples:

[hą:f] 'half' ; [hą:t] 'heart'; [ą:ə] 'hour' " (p.42)

He concludes that "nasality and glottality are interrelated in such a variety of ways that it is imperative to search for an explanation in terms of universal articulatory fact." (p.42).

J. Ohala, citing many of the same examples as Hetzron and Matisoff, makes the following comments: "Velar height for vowels varies directly with the 'height' of the vowel (in the absence of any neighboring nasal consonant). Thus the so-called low 'oral' vowels may have an opening of the velopharyngeal port. Glottal consonants such as [ʔ] and [h], however, seem to require neither raised nor lowered velum but instead allow the velar elevation to be determined by neighboring consonants and vowels ... It is clear that the combination of glottal consonant plus low vowel is particularly vulnerable to nasalization." (1972: 1167-8).

None of the evidence offered by Hetzron, Matisoff or J. Ohala, however, show that it is the glottal (or pharyngeal) consonants that are directly responsible for the nasalization of adjacent vowels. As J. Ohala indicates, low 'oral' vowels are themselves particularly vulnerable to nasalization, so it should come as no surprise that "the combination of glottal consonant plus low vowel" should be equally vulnerable. That is, J. Ohala has shown that glottal consonants which are neutral with respect to velic

opening, are compatible with vowel nasalization, unlike non-glottal consonants, which require velic closure. What he has not demonstrated is that glottal consonants themselves play an active role in the nasalization process.

The preceding discussion should not be interpreted as denying that far and away the most common origin of NV's is from earlier NC's as Ferguson's universal 14 indicates. With regard to the principle source of NV's (from NC's) we might simply note that the nasalizing NC may either precede or follow the vowel which is nasalized, and is usually tautosyllabic with it. It appears that normally the NC follows the vowel, but on occasion may precede. Practically all FRENCH NV's and most PORTUGUESE NV's derive from following NC's (however, cf. PORTUGUESE [mĩ] 'me' < LATIN mihi), but Hyman (1972) argues convincingly that in the KWA languages the original NC's preceded the vowels that were eventually nasalized.

3 The origin and development of nasal vowels

In this section I will describe the process through which systems of NV's arise, change and ultimately disappear. This process may be considered universal in a very loose sense. Were the process of vowel nasalization to take place without interference from the rest of grammatical structure, it would most likely pass through the stages outlined here. However, since there are always many diverse pressures bearing on a language at any given point in time, and since different pressures may push the structure of the language in different directions, only rarely, if ever, do we find NV's developing with no aberrations from the 'normal' course of development. That is to say, the universal process of vowel nasalization usually interacts with other (universal) processes to produce sound patterns which are in part language specific.

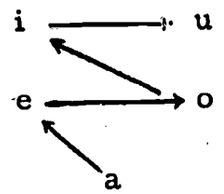
In general, we may break the process of vowel nasalization into three phases:

1. Nasalization
2. Nasal Consonant Deletion
3. Denasalization

The first phase of the nasalization process begins when a vowel preceding a NC comes to be pronounced with the velum lowered. Typically, the vowel is low (i.e. a), and the NC is tautosyllabic. The naturalness of this phonological process derives from two factors. First, the velum is simply lowered a bit early through anticipation of the following NC. Secondly, the degree of velic opening is normally greater in low vowels than in high vowels so that nasalization thereby has a natural inroad on low vowels. What happens, then, is not that formerly pure oral vowels are nasalized, but rather the earlier slight nasalization, which is a property of all low vowels to some extent, now becomes accentuated. Once the nasalization of the low vowel(s) is well established (perhaps to the extent that it must be specified by a language specific phonological rule), the

environment for nasalization is progressively simplified, spreading first to the mid vowels and lastly to the high vowels, with front vowels normally undergoing nasalization before back vowels. We might represent this process as follows:

(7)



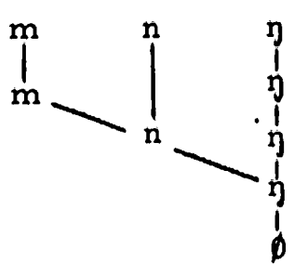
At this stage all of the vowels will be phonetically nasalized when preceding a NC.

The development of NV's in FRENCH followed the above chronology rather closely (cf. Pope, 1934: 166-82). a̲ was the first vowel nasalized, probably as early as the tenth century. During the eleventh century e̲ also begins to show nasalization. Finally, the three high vowels, i̲, ü̲, and u̲, were nasalized starting in the thirteenth century. Chen (1971, 1973) posits a similar chronology for CHINESE dialects, and Jackson (1967) reports that in BRETON phonemic vowel nasality arose first with a̲. I have been unable to determine the order in which vowels were nasalized in PORTUGUESE and the INDO-ARYAN languages. The POLISH NV's ([ɛ̃] and [ɔ̃]) derive, indirectly, from the PROTO-SLAVIC NV's ẽ and õ. Historical data are, of course, lacking for most AFRICAN and AMER-INDIAN languages.

It may be the case that the chronology for vowel nasalization presented in (7) is also valid for child language acquisition. Bloch (1913: 51-2) indicates that the four FRENCH NV's appeared in the speech of his daughter in the following order: æ̲̃, ɑ̲̃, õ̲, œ̲̃.

During the second phase of vowel nasalization the NC's gradually merge and are finally lost in certain environments, often with compensatory lengthening of the NV. Following Chen (1973), we may hypothesize that syllable final NC's merge front to back:

(8)



In addition to the support from CHINESE that Chen (1973) adduces for (8), FRENCH also appears to have followed the same path. First, m̲ and n̲ merged to n̲ in OLD FRENCH; next n̲ was dentalized. Finally, all syllable final NC's became velar. Even today the FRENCH spoken

in the south of France is characterized by a slight velar NC so that what is pronounced [tã] 'time' in PARISIAN FRENCH, is often [tãᵑ] in the Midi. Similarly, in PROVENÇAL the only syllable final nasal is [ŋ] (cf. Coustenoble, 1945). Furthermore, in certain AMERICAN SPANISH dialects word final n has been velarized: e.g. bien [bjen] 'good' > [bjeŋ]. Finally, Needham and Davis (1946) report that word final NV's in CUICATECO often show a velar offglide [ᵑ].

Of course, not all NC's merge and are deleted; at least two factors seem to play a role here:

1. The position of the NC in the word.
2. The nature of the following segment (if any).

With respect to 1 it appears that preconsonantal NC's are lost first; second, word final NC's are deleted when followed by a consonant; and third, the remaining word final NC's are deleted. Lastly, intervocalic NC's may be lost (as in PORTUGUESE), but such consonants are probably retained more often than not, possibly because their deletion creates a more complex syllable structure (e.g. CṼV), whereas the deletion of NC's in other environments leads to open syllable structure (e.g. CVNCV → CṼCV), which I assume is the least marked.

With regard to 2 the evidence is somewhat conflicting. It would be natural to assume that NC's would be lost first before fricatives, and only later before stops and affricates. Were this the case, we could say that the non-continuant nature of the NC was being assimilated to the continuant nature of the following fricative:

$$\begin{bmatrix} N \\ -\text{cont} \end{bmatrix} \begin{bmatrix} C \\ +\text{cont} \end{bmatrix} \rightarrow \begin{bmatrix} N \\ +\text{cont} \end{bmatrix} \begin{bmatrix} C \\ +\text{cont} \end{bmatrix}$$

The effect of this would be the deletion of the nasals. Later the environment for nasal deletion would be generalized to include non-continuant consonants as well. Putative support for the above chronology might come from POLISH and PORTUGUESE, where NC's following NV's have been lost only when followed by continuants. When followed by non-continuants there is a NC homorganic with the non-continuant. In the ROMANCE languages LATIN ns is often reduced to s (e.g. LATIN mensa 'table' > RUMANIAN masă, FRENCH moise, SPANISH, PORTUGUESE mesa), though it is not clear that the preceding vowel was ever nasalized. In INDO-ARYAN, NC's were generally lost before continuants, with lengthening and nasalization of the preceding vowel (what SANSKRIT grammarians call 'anunasika'), but were retained in the form of a homorganic NC before non-continuants ('anusvara'). Furthermore, INDO-ARYAN languages indicate that homorganic NC's are lost first before voiceless stops, and only later, if at all, before voiced stops (with respect to HINDI, cf. M. Ohala, 1972: 181-4). Some varieties of AMERICAN ENGLISH support this chronology: [kæ̃t] 'can't', but [kæ̃nd] 'canned'.

On the other hand, Malecot (1960) points out that in certain varieties of AMERICAN ENGLISH NC's are not lost before fricatives (e.g. *[dɛ̃s] 'dense'), but may be before stops (e.g. [kæ̃t] 'can't').

A related problem lies in determining whether the slight NC in groups such as

$$\tilde{V}^{N}[C, -\text{continuant}]$$

represents (1) a trace of what is phonologically a full NC, or (2) a kind of transitional nasal glide, which has no underlying status, and which appears simply through 'articulatory convenience'. For example, in PORTUGUESE, we might ask what native speakers 'hear' when a word like [kə̃^{m}pu] 'field' is pronounced. According to Morais-Barbosa (1962: 703), educated people say this word has five sounds, while illiterates report only four. Hammarstrom (in Morais-Barbosa, 1962: 709) claims that he frequently finds it difficult to persuade PORTUGUESE speakers that they do in fact pronounce an [^{m}] in [kə̃^{m}pu]. Kailionen (in Morais-Barbosa, 1962: 704) reports that upon asking a peasant to divide campo in syllables, the peasant responded with [kə̃m] + [p^{u}], with a very clear [m]. The evidence is, therefore, conflicting as to whether [^{m}] in [kə̃^{m}pu] derives from rule 9 or 10:

(9) $N \rightarrow {}^{N}/\ \tilde{V}\_\_\ [C, -\text{continuant}]$
(10) $\emptyset \rightarrow {}^{N}/\ \tilde{V}\_\_\ [C, -\text{continuant}]$

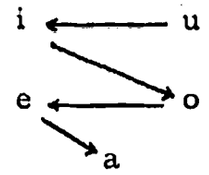
The choice of (9) or (10) depends, of course, on whether the proper phonological representation is /kəmpu/ or /kə̃pu/; we shall return to this question in section 4.

After the deletion of NC's in various contexts, vowel nasality is no longer allophonic, but is rather phonemic in that surface contrasts between an oral vowel and its nasal partner are now possible. Such NV's may or may not be phonological, depending on whether or not the nasality of the vowel can be motivated in terms of morphophonemic structure, or other general principles. Thus, for example, in FRENCH nasality would be an inherent feature of the vowel in on [õ] 'one', but would be derived in bon [bõ] 'good'.

The third and final phase of vowel nasalization is denasalization, which occurs in two parts. First, vowel nasality is lost where it has remained allophonic (i.e. redundant). Secondly, nasality may be lost even where it has attained the status of an underlying feature.

During the first part of phase three, NV's are denasalized if, and only if, they are still followed by NC's. It is this kind of denasalization which, in FRENCH, produced [bɔnə] from earlier [bõnə]. The order in which vowels are denasalized is the reverse of that in which they were nasalized:

(11)



Denasalization in FRENCH before intervocalic NC's, a process which took place from the fifteenth to seventeenth centuries (cf. Pope, 1934:170-2), did not follow precisely the path indicated in (11). Rather the first vowels denasalized, in the fifteenth century, were ĩ and ɛ̃, followed in the sixteenth century by first ũ and later ã. õ was the last vowel to be denasalized, toward the end of the seventeenth century.

Finally, the phonological NV's may themselves be denasalized. That is, nasality as an inherent feature of vowels is eliminated from the lexicon. Again the order in which NV's disappear is the reverse of the order in which they arose (cf. (11) above). Chen (1971, 1973) provides support from CHINESE dialects for the notion that NV's are denasalized in the reverse order from that in which they were nasalized. The BRETON dialects also provide supporting evidence for this hypothesis. In the TRÉGORROIS dialect ɑ̃ has been denasalized, but the other NV's remain (i.e. ĩ, ũ, ɛ̃, õ, ã). In the VANNETAIS and LÉONAIS dialects all of the high NV's have been lost, but the mid and low NV's have not yet been affected. Finally, in the ILE DE GROIX dialect only the low NV ã is preserved. Pandit (1972) indicates that in GUJARATI diphthongs the first NV to be denasalized was the high NV ĩ, and Sardesai (1930) notes the early denasalization of the high NV ĩ in MARATHI. In both OSAGE and SIRIONO ɑ̃ is missing from the series of high NV's, and F. Trager (1971) reports finding only one instance of /ɑ̃/ in PICURIS, and therefore suggests that the sound change ɑ̃ > u is currently taking place.

Wierzchowska and Wierzchowska (1969) point out that in POLISH denasalization may at times be conditioned by semantic factors. Thus, the /õ/ in mąż /mõs/ 'a man' remains nasalized in mąż stanu 'statesman', but is frequently denasalized in a context like mąż pani X 'the husband of Mrs. X'. Similarly, wąż is denasalized to [vows] when it means 'rubber pipe', but retains nasality when its meaning is 'snake'.

There is, of course, no fundamental mystery as to why NV's should ultimately disappear. NV's are certainly phonologically (and phonetically) more complex than oral vowels, and consequently their loss means that marked segments revert to their normal unmarked state.

During the three phases of vowel nasalization outlined above, other factors may come into play which result in certain language specific aberrations in the general pattern of vowel nasalization. We have already discussed in section 2 Greenberg's universal of preferential merger. The languages we have investigated leave no doubt that there is a strong tendency for NV's to merge, and consequently for oral vowel systems to be richer,

in general, than systems of NV's. Furthermore, it seems likely that the way in which NV's merge is itself constrained by certain universal principles. For example, in a number of different languages the NV corresponding to the oral pair e/ɛ assumes the place of articulation of the lower oral vowel. In other words, in languages which have oral [e] and [ɛ] the nasal counterpart is usually [ɛ̃] (e.g. FRENCH, GUJARATI, OGONI, SCOT'S GAELIC, SENECA, TEWA, and YORUBA). Furthermore, in some languages which have e and o, but no ɛ or ɔ, the corresponding NV's are in fact perceptibly lower than the oral vowels (i.e. [ɛ̃] and [ɔ̃]) (e.g. BRETON, CHATINO, and POLISH). On the other hand, the nasal partner of [a] is sometimes higher than its oral counterpart (e.g. PORTUGUESE, YORUBA, IOWAY-OTO, NUPE, and PICURIS). It is difficult to carry investigations along this line too far, however, because the precise phonetic quality of NV's is often ignored in the available literature. Very often the oral vowels are listed first, and the NV's are then described in terms of the oral vowels, whether the place of articulation is truly the same or not (cf. the frequent use of [ẽ] and [ɛ̃] to represent the FRENCH NV which is phonetically [æ̃]).

Another factor influencing the evolution of NV's is their supposed predilection for lowering. Though much cited in the literature, and frequently stated in almost universal terms (especially by scholars primarily concerned with FRENCH), the languages we have investigated offer relatively little evidence that NV's do in fact tend to lower in any systematic way. Here and there we do find NV's being lowered, and the FRENCH examples are indisputable, but given so many languages with only high and low NV's, it would appear somewhat difficult to reconcile the frequency of such systems with a universal tendency toward lowering.

A third factor which appears to interfere with the normal development of NV's is the labialization, and subsequent raising, of low NV's. Not infrequently certain NV's develop a w offglide (PORTUGUESE and POLISH are two well known examples). If we then assume that a nasal diphthong such as [ãw] might naturally evolve first to [ɐ̃w], then [ɑ̃w], and finally [ɑ̃], a number of disparate facts may be explained. First of all, such an evolution seems indicated in the case of PROTO-ATHAPASKAN */an/, which has evolved in HARE to /ɑ̃/ (with /ã/ being practically eliminated) (cf. Hoijer, 1966:507). Ferguson (personal communication) informs me that PERSIAN also offers examples of original ã being raised to ɑ̃, so that the capital of Iran, while still written Teheran, is often pronounced with the NV [ɑ̃] in the final syllable. Andrews (1949) observes that in TEMOAYAN OTOMI ɑ̃ is much more frequent than its oral partner u, and it seems at least plausible that such a situation might be explained by the labialization process here being described. Perhaps also it is this process which accounts for the strange configuration of NV's in ONEIDA, where the sole NV's are ɑ̃ and ʌ̃, neither of which has an oral partner. In GUJARATI we find original *akam has evolved to [ɑ̃] in the modern language,

and the earlier endings -ãmi and -ãma have merged to [ũ] (though original -ãni, with a dental rather than labial NC, remained low: [ã]). Finally, we might take note of the situation in USILA CHINANTEC. According to Skinner (1962) the NV /ũ/ is realized phonetically as a bilabial syllabic nasal [m̩]. If [m̩] is not phonemicized as /ũ/, then oral /u/ has no nasal counterpart. Furthermore, Skinner claims that [m̩] occurs precisely where one would expect [ũ]. All of these facts, then, would seem to indicate a connection between labiality and nasality which may result in deviations from the normal nasalization process.

In some languages it appears that the feature [+nasal], originally a feature of individual segments, may in time become a feature of entire morphemes. Firthian linguists were probably the first to recognize the 'prosodic' nature of nasality in certain languages. Robins (1953, 1957) presented such an analysis for SUNDANESE (cf. more recently Anderson, 1972), and Bendor-Samuel (1960) discussed a similar phenomenon in TERENA. More recent treatments along this line include Kaye (1971) on DESANO, and Lunt (1973) on GUARANI. Lunt (1973: 138) makes the interesting suggestion that CONTINENTAL PORTUGUESE may now be in the process of extending the feature of nasality from segments to syllables and morphemes.

4. Synchronic aspects of vowel nasalization

The principle task for synchronic studies of vowel nasalization has traditionally been to determine when the feature [+nasal] is inherent in a vowel, and when it is not. This is not to say that other lines of research are devoid of interest, but simply that past work has by and large relegated questions other than the 'inherentness' of vowel nasality to the periphery. Clearly, the function that nasality may fulfill in a grammar is an equally important question, but one which has received nowhere near the same amount of attention.

One obvious difference in the use of NV's by various languages is that in some languages NV's play a morphological role, while in other languages they merely serve to distinguish morphologically unrelated lexical items. For example, in the TRÉGORROIS dialect of BRETON vowel nasality differentiates the first singular form of verbs from the second singular:

[pərĩ] 'when I shall do'
[pəri] 'when thou wilt do'

In BENGALI the presence of nasality may be used to show deference:

[tar] 'his'
[tãr] 'his' (honorific)

CHATINO also offers cases of nasality functioning as a morph:

[mbilyi]	'your comadre'	[lsu]	'your beard'	[suwe]	'your chin'
[mbilyĩ]	'my comadre'	[lsũ]	'my beard'	[suwẽ]	'my chin'

M. Ohala (1972) offers the following examples from HINDI-URDU:

[hɛ̃] 'is' [čoli:] 'she went'
[hɛ̃] 'are' [čolĩ:] 'they went'

In other languages nasality may fulfill a purely lexical function. Furthermore, vowel nasality may have sociolinguistic import. Pandit (1972) reports that in some varieties of GUJARATI the use of vowel nasalization marks the speaker as a member of the higher classes.

Let us now return to the problem of determining when nasality is inherent in a vowel, and when it is derived. Prestructuralist linguists have been criticized for simply indicating nasality where it was physically present, and for not attempting to distinguish those cases where nasality was functional from those cases where it was allophonic. With the advent of structuralist phonemics, most linguists came to recognize that the feature of nasality could be used in two fundamentally different ways. On the one hand, it could serve to distinguish one form from another. When used in this way, it was said to be phonemic. On the other hand, in some languages nasality could be physically present in the speech signal without having the power to differentiate forms. Such nasalization was allophonic. Thus structural linguists posed for the first time the problem of determining when vowel nasality is inherent (i.e. phonemic), and when it is not. It must be recognized, however, that there was no single structuralist answer to this question. European structuralists, in general, permitted the use of criteria which were rejected in the United States. One fundamental dispute between the two groups of linguists concerned the admissibility of non-phonetic factors in dealing with phonological phenomena. Most Americans insisted that phonology be kept independent of the rest of the grammar (Pike is a notable exception), while Europeans usually argued against any such separation of levels.

With the rise of transformational grammar, many American linguists came to reject the doctrine of separation of levels as totally unjustified. By denying this doctrine it was now possible to reinterpret the nasality in certain NV's as being conditioned rather than inherent. Where previously nasality had been considered inherent unless it was phonetically conditioned, generative phonologists relaxed this restriction somewhat. They argued that the feature nasality was inherent only if it was neither phonetically conditioned, nor grammatically conditioned. The result of this was that in a NV such as is found in FRENCH bon [bõ] 'good', the feature [+nasal], which had earlier been considered inherent, was now held to be conditioned, not by phonetic structure, but by morphophonemic structure, because this form is paradigmatically related to the feminine form bonne [bɔn] 'good'.

In their euphoria over having made predictable features which earlier linguists had considered unpredictable, certain scholars went so far as to declare that "the nasal contrast is not known to occur with vowels at the phonemic level. In the systematic phonemic analyses of languages with

nasal vowels (such as French, Igbo), the interpretation of these as vowel plus nasal consonant has consistently proved superior to the unit nasal vowel solution." (Harms, 1968:36). Using FRENCH as an example, the argument that vowel nasality is never inherent runs as follows (cf. Schane, 1968a:45-50, and fn. 37, p.142). Since a phonological description of FRENCH must, in any event, contain the segments /a/ and /n/ on the phonological level, and since [ɑ̃] clearly derives from /an/ in plan [plɑ̃] 'flat' (because of the inflectionally related form plane [plan] 'flat'), our phonological description will be 'simpler' if we use the rule which derives [ɑ̃] from /an/ in plan to derive all instances of [ɑ̃]. In this way NV's may be entirely eliminated from the lexicon.

One obvious defect in this approach, however, is that it assumes a priori that one of the goals of a phonological description is the elimination of certain kinds of segments at the phonological level. (The early transformational bias for economy in the lexicon over economy in the phonological rules is well known; it seems likely that this bias was a legacy of the structuralist period.) But such an assumption seems to me no more justified than the a priori structuralist assumption that phonology and grammar are independent.

Furthermore, the elimination of all NV's from the lexicon leads to problems which have not yet been satisfactorily resolved. For example, since [ɑ̃] derives from /an/ in plan, but from /ɛn/ in prendre [prɑ̃drə] 'to take' (cf. prennent [prɛn] 'they take' (subj.)), what does en [ɑ̃] 'in' derive from, /an/ or /ɛn/? Is there any way to make the choice of either /an/ or /ɛn/ non-arbitrary?

One suggested solution to this problem is to allow markedness considerations determine the underlying form in cases of structural ambiguity. Thus Schane (1968b) proposes that [ɑ̃] in en derive from /an/, not /ɛn/, because a is less marked than ɛ. While markedness does provide us with an answer, there has so far been very little empirical support which would demonstrate that it is the right answer. In fact, Vennemann (1972) discusses several examples where the use of Schane's markedness principle leads to intuitively incorrect analyses.

A different remedy to the problem of indeterminacy is the Alternation Condition advocated in Kiparsky, 1968, whose effect on NV's would be to make the feature [+nasal] inherent in those vowels which do not alternate morphophonemically with an oral vowel + nasal consonant. Thus en [ɑ̃] would derive directly from phonological /ɑ̃/.

However, in a number of languages (e.g. FRENCH, PORTUGUESE, and HINDI-URDU), certain phonological rules presuppose a /VN/ analysis for NV's which do not show any morphophonemic alternation. For example, the phonological rule of FRENCH which is responsible for voicing -s- in résister [reziste] 'to resist' (cf. persister [persiste] 'to persist', where s remains voiceless), presupposes a phonological analysis for insister

[ɛ̃siste] 'to insist' where -s- is not intervocalic, as it is phonetically. Were /ɛ̃/ underlying in this verb, then the intervocalic -s- voicing rule would have to be complicated by distinguishing NV's from oral vowels in order to prevent the derivation of *[ɛ̃ziste] from phonological /ɛ̃+sis+te/. The problem, then, is one of deciding whether NV's only act like closed syllables (in which case the s voicing rule will have to be complicated as indicated above), or whether NV's are, in fact, closed syllables at some point in the derivation (in which case the s voicing rule may retain its full generality).

In PORTUGUESE, syllables with NV's act like closed syllables with respect to several rules of the grammar:

(a) PORTUGUESE has two r phonemes: alveolar r and uvular (or velar) R, which contrast only intervocalically: [muru] 'wall' ~ [muRu] 'punch'. Elsewhere they are in complementary distribution, r occurring only after a tautosyllabic consonant (e.g. prato 'plate') or at the end of a syllable or word (e.g. Carlos, mar 'sea'), and R word initially (e.g. rei 'king') or after a heterosyllabic consonant (e.g. guelras 'gills'). However, in the context $\tilde{V}$__V, we find only R, never r: genro [žẽRu] 'son-in-law'; honra [õRə] 'honor'. We can explain the presence of only R if we assume that [žẽRu] derives from /ženRu/, [õRə] from /onRə/, etc.

(b) /b, d, g/ each have two allophones in PORTUGUESE: [β, ð, ɣ] intervocalically and [b, d, g] elsewhere. Now in words such as rombo 'blunt', senda 'path', and vingar 'to avenge' we always find [b, d, g]. Thus [b, d, g] are realized after NV's exactly as if they were following a consonant.

(c) PORTUGUESE frequently merges two adjacent vowels: cidade antiga [sidadantirə] 'old city'. However, a NV + oral vowel never contract: lã azul [lɐ̃əzuɫ] 'blue wool'. Again it would seem that [ɐ̃] should be analyzed as /ən/.

However, if we do accept that NV's in PORTUGUESE should be represented on the phonological level as a sequence of oral vowel + NC, we are faced with the problem of determining what the NC is. There are actually two problems here. The first is to determine how to represent the homorganic nasal in words like: campo 'field', senda, vingar. Transformational studies have generally shied away from the use of the archiphoneme N on the phonological level, but is the choice of /n/ (dictated by markedness considerations) really better?

The second problem is to decide what the underlying NC is when phonetically there is no NC at all. Here there are two cases: (1) the NV precedes a continuant: [žẽRu], [kɐ̃furə] 'camphor', [gõzu] 'hinge'; (2) the NV is word final: [bẽ] 'good', [fĩ] 'end', [bõ] 'good'. In three recent generative studies of PORTUGUESE phonology (St. Clair, 1970; Saciuk, 1970; Brasington, 1971) the indeterminacy of the NC which nasalizes vowels has simply been ignored.

In Narang and Becker, 1971, the authors argue that while the dialect of HINDI-URDU which they are considering has seven NV's and five NC's phonetically, practically all of the NV's and three of the NC's are derived from a phonological structure which has only oral vowels and two NC's: /m/ and /n/. They first motivate a phonological rule which deletes schwa in a certain environment:

(12) ə → ∅ / VC __ C + V

Schwa is deleted only if preceded by a single consonant (a consonant cluster blocks the rule). However, rule 12 fails to apply in the context: $\tilde{V}C\_\_C+V$. They then attempt to provide a natural explanation for the failure of schwa to be deleted in this context by analyzing NV's phonologically as /VN/, and allowing rule 12 to precede the rules which turn sequences of /VN/ into NV's. Thus, the phonetic form [ãgənõ] 'courtyards' (obl. pl.) would be derived roughly as follows:

	/āngən+ōn/
Schwa Deletion	---
Nasalization Rules	ãgən+õ
	[ãgənõ]

By representing what is phonetically a NV as an underlying sequence of oral vowel + nasal consonant, the authors are able to provide a natural explanation of why [ãgənõ] is an apparent exception to rule 12. (We should mention, however, that M. Ohala (1972:204) disputes this analysis.) As in FRENCH and PORTUGUESE, once again a phonological rule requires a /VN/ analysis of NV's if the phonological rules in question are to assume their most general form.

In conclusion, we might observe that the general trend over the past several decades has been to eliminate [+nasal] as an inherent feature of vowels. It was first eliminated everywhere it was phonetically predictable. Next is was eliminated wherever it was either phonetically or grammatically conditioned (with the term 'grammar' being understood in its broadest sense). If, after eliminating all grammatically conditioned NV's from the lexicon, there are still indications that the feature [+nasal] should be derived in yet other forms (as the FRENCH, PORTUGUESE, and HINDI-URDU examples cited above appear to indicate), it would seem rather doubtful that further language specific considerations would be of much use. Rather it will be necessary to discover universal principles if we are to further restrict those cases where the feature [+nasal] is considered an inherent property of vowels. In fact, Schane's markedness principle is just such a universal constraint, though unfortunately it does not appear to be empirically adequate. If past history is any indication, then the ebb and flow of abstract and concrete analyses may be with us for some time to come.

APPENDIX

AKAN (Ghana: Niger-Congo: Kwa)

i I e ɛ ə a u U o ɔ ĩ Ĩ ə̃ ã ũ Ũ	No NC's

AMAHUACA (Peru)

i ï a o ĩ ĩ ã õ	m n

(CHIRICAHUA) APACHE (New Mexico)

i e a o ĩ ẽ ã õ	m n

ASSINIBOINE (Montana)

i e a u o ĩ ã ũ	m n

BAULE (Niger-Congo: Kwa)

i I e a u U o ĩ Ĩ ã ũ Ũ	

BEEMBE (Congo: Niger-Congo: Benue-Congo)

i e a u o ĩ ẽ ã ũ õ	m n

BENGALI (India: Indo-Aryan)

i e æ a u o ɔ ĩ ẽ æ̃ ã ũ õ ɔ̃	m n ŋ

BRETON: Léonais dialect (France: Celtic)

i e ü ø a u o ẽ õ ã õ	m n ɲ

BRETON: Île de Groix dialect (France: Celtic)

i e ü ø ə a u o (ẽ) ã	m n ɲ ŋ w̃

BRETON: Trégorrois (France: Celtic)

i e ɛ ü ø ə a u o ɔ ĩ ẽ ũ ã õ	m n ɲ

BRETON: Vannetais dialect (France: Celtic)

i e ɛ ü ø ə a u o ɔ ẽ ã õ	m n ɲ

CASHIBO (Peru: Pano)

i e ɨ a o ɔ	m n ɲ
ĩ ẽ ɨ̃ ã õ ɔ̃	

CHATINO (Mexico)

i e a u o	m
ĩ ẽ ũ õ	

CHINANTEC (Mexico)

i e ɨ ə a u o	m n ŋ
ĩ ẽ ɨ̃ ə̃ ã ũ õ	

CUICATECO (Mexico)

i e ɛ u o a	m n
ĩ ẽ ɛ̃ ũ õ ã	

FRENCH (France: Romance)

i e ɛ ü œ ø a ə u o ɔ	m n ɲ
ɛ̃ œ̃ ɑ̃ õ	

GOAJIRO (Columbia)

i e ə a u o	m n
ĩ ẽ ə̃ ã ũ õ	

GUARANI (Paraguay)

i e ɨ a u o	m n ɲ ŋ $ŋ^{w}$
ĩ ẽ ɨ̃ ã ũ õ	

GUJARATI (India: Indo-Aryan)

i e ɛ ə a u o ɔ	m n ɳ N
ĩ ɛ̃ ə̃ ã ũ ɔ̃	

GUN (Niger-Congo: Kwa)

i e ɛ a u o ɔ	No NC's
ĩ ɛ̃ ã ũ ɔ̃	

HARE (Canada: Athapaskan)

i e a u o	m n
ĩ ẽ (ã) ũ	

HINDI-URDU (India: Indo-Aryan)

i e æ a u o ɔ	m n ɳ ɲ ŋ
ĩ ẽ æ̃ ã ũ õ ɔ̃	

IOWAY-OTO (Oklahoma)

i e a u o	m n ɲ ŋ
ĩ ã ũ	

ISLAND CARIB (British Honduras)

i e a u o	m n
ĩ ẽ ã ũ õ	

JIVARO (Ecuador)

i ɨ a u	m n ŋ
ĩ ɨ̃ ã ũ	

KAIWA (Brazil: Guarani dialect)

i e ɨ a u o	No NC's
ĩ ẽ ɨ̃ ã ũ õ	

KPELLE (Liberia: Niger-Congo: Mande)

i e ɛ a u o ɔ	m n ŋ
ĩ ẽ ɛ̃ ã ũ õ ɔ̃	

MAZAHUA (Mexico: Otomi)

i e ɛ ʌ ə a u o	m n ɲ
ĩ ẽ ə̃ ã ũ õ	

MOTILONE (Columbia)

i e ï a u o	m n
ĩ ẽ ï ã ũ õ	

NUPE (Nigeria: Niger-Congo: Kwa)

i e a u o	m n
ĩ ã ũ	

OCAINA (Peru)

i (e) ï a o	m n ɲ M N Ɲ
ĩ ĩ ã õ	

OGONI (Nigeria: Niger-Congo: Benue-Congo)

i e ɛ a u o ɔ	m n
ĩ ɛ̃ ã ũ ɔ̃	

OJIBWA (Michigan: Algonquian)

i e a o	m n
ĩ ẽ ã õ	

ONEIDA (Wisconsin: Iroquois)

i e a o	n
ʌ̃ ũ	

OSAGE (Okalahoma)

i e a u o ĩ ã õ	m n

OTOMI (Mexico)

i e ɛ ʌ ə a u o ɔ ĩ ã ũ	m n ɲ

PAME (Mexico)

i e ɛ a o ĩ ẽ ɛ̃ ã õ	m n ŋ

PICURIS (New Mexico)

i e ə a u o ĩ ẽ ə̃ ã (ũ) õ	m n

POLISH (Poland: Slavic)

i e a u o (ẽ) õ	m n ɲ

PORTUGUESE: Brazilian (Brazil: Romance)

i e ɛ a u o ɔ ĩ ẽ ɐ̃ ũ õ	m n ɲ

PORTUGUESE: Continental (Portugal: Romance)

i e ɛ ə a u o ɔ ĩ ẽ ɐ̃ ũ õ	m n ɲ

SCOT'S GAELIC: Skye dialect (Scotland: Celtic)

i e æ ɪ̈ ə a u o ɔ ĩ æ̃ ɪ̃ ã ũ ɔ̃	m n ŋ

SENECA (New York)

i e æ a o ẽ ʊ̃	n

SERI (Mexico)

i e a o ĩ ẽ ã õ	m n ŋ

SIRIONO (Bolivia: Guarani dialect)

i e ɨ a u o ĩ ẽ ɨ̃ ã õ	m n ɲ ŋ

SLAVE (Canada: Athapaskan)

i e a u o ĩ ẽ ã ũ õ	m n ɲ

TEWA (Arizona: Tanoan)

i e a u o	m n
ɾ̃ ẽ ã ũ õ	

TEWA: Santa Clara dialect (New Mexico: Tanoan)

i e ɛ a u o	m n ɲ
ɾ̃ ɛ̃ ã ũ	

TOLOWA (Athapaskan)

i e a u	m n
ɾ̃ ã ũ	

USILA CHINANTEC (Mexico)

i e a u o	m n ɲ ŋ
ɾ̃ ẽ ã ũ õ	

WARAO (Venezuela)

i e a u o	m n
ɾ̃ ẽ ã ũ õ	

WAUNANA (Panama: Choco)

i e ĭ a u o	m n
ɾ̃ ẽ ĩ ã ũ õ	

YANKTON-TETON (Dakota dialect)

i e a u o	m n
ɾ̃ ã ũ	

YORUBA (Nigeria: Niger-Congo: Kwa)

i e ɛ a u o ɔ	m
ɾ̃ ɛ̃ ũ ɔ̃	

YUCHI (Oklahoma)

i e ä u o a	n
ɾ̃ ẽ ä̃ ũ õ ã	

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Abbreviations:

BSOAS	Bulletin of the School of Oriental and African Studies
IJAL	International Journal of American Linguistics
JRAS	Journal of the Royal Asiatic Society
POLA	Project on Linguistic Analysis

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WORKING PAPERS ON LANGUAGE UNIVERSALS

Number Twelve
November 1973

Language Universals Project
Committee on Linguistics
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Stanford, California